

JANUARY 2015

ASUS Eye Care Technology White Paper



Eye Care

ASUS EyeCare Technology is a brand name built on two fundamental technologies that help prevent Computer Vision Syndrome (CVS); Flicker-free and Low Blue Light. The two are complementary and the best strategy in reducing CVS, as the increasing reliance on smartphones, tablets, laptops and PCs in all aspects of everyday life puts us in front of displays for an increasing number of hours. With pro-longed use, the issue of user comfort and eye health becomes an increasingly issue and users are keen to ensure they avoid any possible discomfort or health issues.

While a myriad of factors can affect eye health and comfort when using a display, several require user interaction and setup optimally; including brightness level, color calibration and ambient lighting from the surround environment. However both Flicker-free and Low Blue Backlight technologies are a part of ASUS' R&D arsenal to bring eye health benefits to ASUS monitor users.



ASUS will continue to introduce display products including flicker-free, low blue backlight technologies and anti-glare coating under the ASUS Eye Care branding.

ASUS Eye Care Branding



ASUS Flicker-free

What is monitor flicker?

In general terms, flicker is perceived by the human visual system when there is a significant change in the brightness of light over a short time interval. The frequency of light-dark-light changes is defined by the number of times per second this change occurs. The ability to observe flicker varies greatly between individuals, and even depends on where a user is looking since peripheral vision is most sensitive.

Monitor flicker has been attributed to issues with CVS since the introduction of the CRT, however CRTs and LCDs have different types of perceptible 'flicker'.

CRT flicker is attributed to the refresh rate of the display; cathode ray gun is fired across the screen, with only part of the screen illuminated at any one time. When this top-to-bottom refresh is too slow it is visible. A refresh frequency of 72Hz or above is commonly considered suitable to eliminate flicker from CRT's for most users (TCO 92).

LCD flicker is different, as LCD's refresh the entire display at once, a 60Hz refresh rate is considered acceptable to most people. Some 4K panels are limited to a 30Hz refresh rate on certain display connections, which is certainly noticeable. Backlight flicker is not the same as perceptible motion blur, where a refresh rate boosted to 120-144Hz and technologies like back-light strobe syncing (Nvidia ULMB) come into play, as a slow backlight can still be perceived with a fast refresh rate.

LCD flicker is sometimes (although rarely) the result of interference when using an analogue d-sub or component connection, rather than a digital DVI, HDMI or DisplayPort which have forms of error-checking to retain signal quality. Virtually all modern LCDs and PCs and notebooks will have some form of digital connection present and DVI, HDMI and DisplayPort can be readily interchanged to match the socket, so these should be used where possible.

Fundamentally LCD flicker is due to the backlight control, where two alternative systems, PWM and DC, are used.

Backlight control: PWM Technology

PWM technology requires a respectively simple circuit design, and thus is cost effective to use. It can easily and accurately scale from high to low brightness and with a fast response rate, especially when dynamic brightness is required. This means it is often preferred and has been used in LCD monitors for many years; however it can produce a visible strobing effect perceived as flicker.

At the maximum brightness setting (100%) where the backlight is illuminated continuously there is no flicker effect. However as the brightness is reduced, to simulate a lower perceived

luminance, the backlight is very rapidly turned off and on. This is done at such a high frequency that in theory it *should* be undetectable for the user, but it often isn't. While the eyes are moving, even with a static image such as in office applications and internet browsing, with black text upon large panes of white background are perhaps most problematic when it comes flicker perception with PWM controlled backlights.

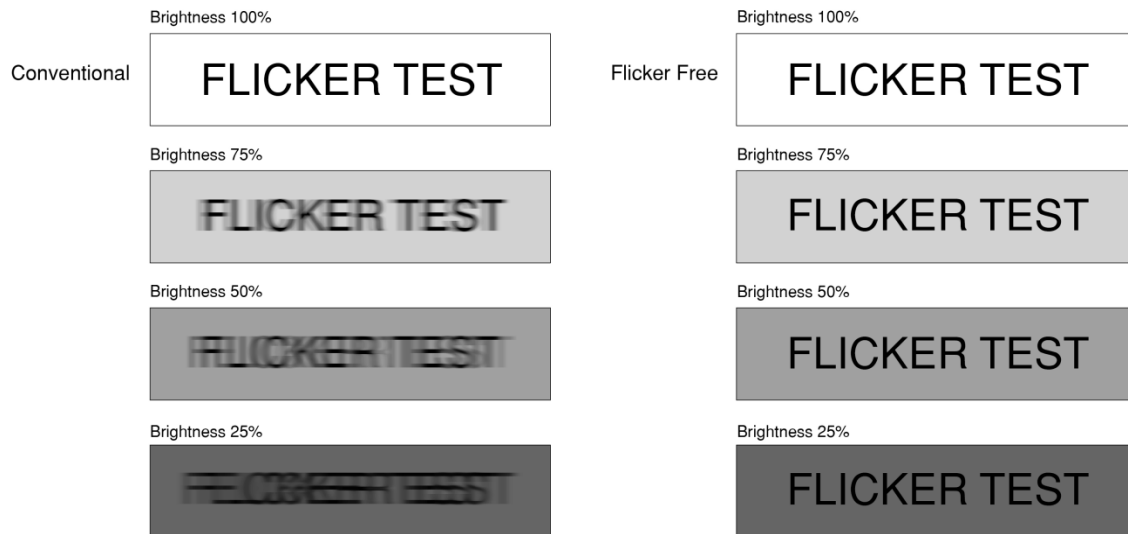
PWM backlight control does enable some unique technologies, such as Nvidia's Ultra Low Motion Blur (ULMB), where the backlight strobe is set to match the refresh rate, so the user never sees the pixel transition state perceived as blur. However, the downside is that since the PWM strobing rate has to be *reduced* to meet the 'high refresh rate' of the LCD panel (120-144Hz versus standard 60Hz), this drops the brightness notably.

Comparison of PWM Visual Flicker

The switch from cold cathode fluorescent light (CCFL) to white LED (WLED) backlights in many monitors was done for the sake of size, efficiency, durability and sometimes cost, but it has also made PWM flicker more pronounced.

CCFL's continue to fluoresce for a short period after the power is removed, producing a slower, smoother dimming effect than WLEDs, which have a much sharper on-off transition. Therefore there is less perceptible flicker with CCFL at slower frequencies than when using WLED backlights.

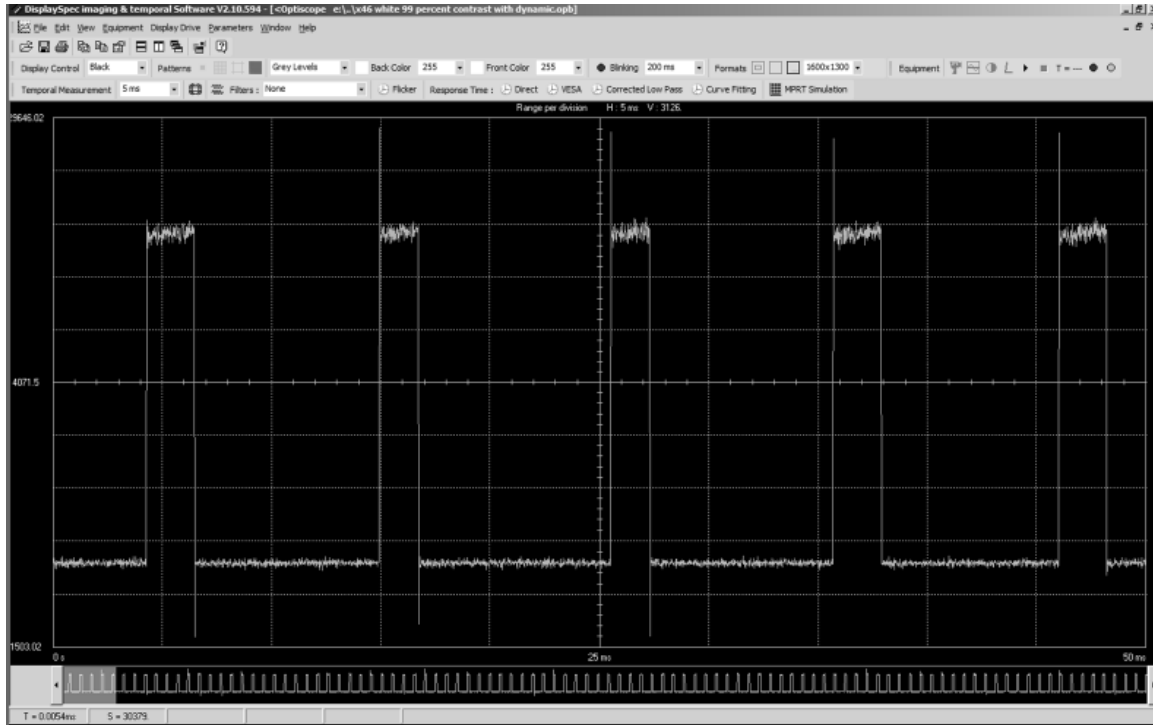
Below are shown examples of how text might appear while the eyes are moving horizontally under different backlights.



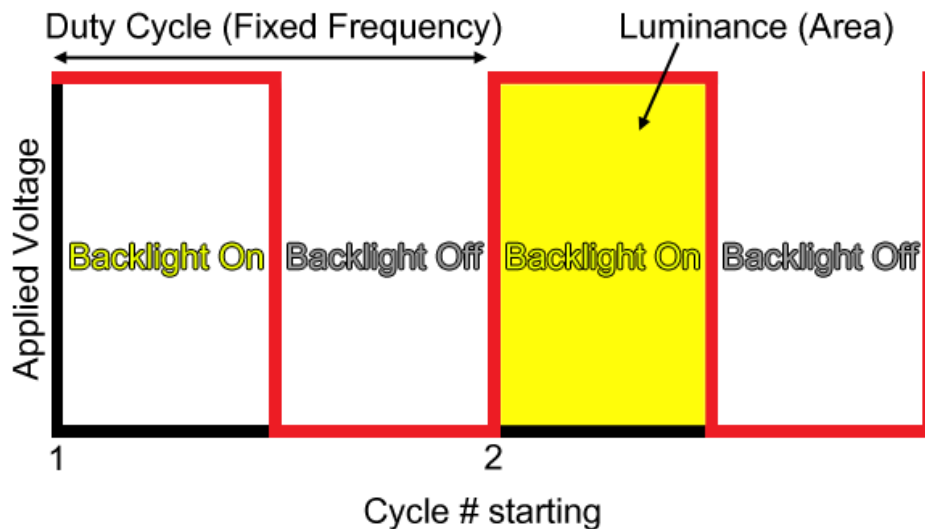
PWM Duty Cycle and Amplitude

Two factors affect the total observed luminance: The 'duty cycle' and amplitude. The Duty Cycle dictates the frequency of backlight switching on-off (strobing) while the Amplitude is

the absolute power output setting and is often controlled by varying the direct current (DC). **The Duty Cycle is fixed.** This means that more current, the more powerful the backlight.



Oscilloscope view of a PWM controlled WLED backlight at 100Hz, courtesy of TÜV Rheinland



Backlight control: Direct Current (DC) Technology

Direct Current (DC) control provides a constant power to the backlight, which eliminates the need for PWM strobing completely. DC control results in the lowest levels of flicker and CVS, and is overall easiest to view for prolonged working conditions.

However its implementation is more expensive and technically complicated to provide. In some cases there is also difficulty controlling the color in darker images if the color temperature of the backlight changes at near-threshold voltage, so DC backlight control has been less common.

How ASUS Displays are now Flicker-free

When you buy an ASUS Display with EyeCare, you are buying a Flicker-free backlight control, which is certified by TÜV Rheinland.

Certified by TÜV Rheinland (2PfG) – A Statement by TÜV Rheinland

TÜV Rheinland is a professional and experienced certification body and the world's leading authority on display testing. TÜV Rheinland has developed a display-specific standard (2PfG) for flicker free and low blue light, for the testing and measurement under different levels of environmental brightness, blue-light strength, wavelength.

This helps manufacturers develop products that are better for consumers' health, where consumers can look for the TÜV Rheinland certification as a sign of confidence and quality, with its own unique ID and QR Code. Customers worldwide can scan the QR Code to view the certification information. Unique 2PfG display quality standard can assist companies in further improving the image quality of their displays.

ASUS Displays with EyeCare technology are certified by TÜV Rheinland. Please see the ASUS website for further information at: <http://www.asus.com/Monitors/> or visit the TUV website for certification: http://www.certipedia.com/quality_marks/0000043082.